

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0427 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 02/22/01

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: SENSOR, ET LH2 BF GOODRICH	MC432-0205-0013 (OR EQUIVALENT ET P/N)
LRU	: SENSOR, ET LO2 BF GOODRICH	MC432-0205-0019 (OR EQUIVALENT ET P/N)
LRU	: ELECTRONICS BF GOODRICH	MC432-0205-0021
LRU	: SENSOR, ORBITER BF GOODRICH	MC432-0205-0027

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

SENSORS AND ELECTRONICS, LO2/LH2 POINT LEVEL, ECO.

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

THIS SYSTEM PROVIDES A MEANS OF MONITORING THE PROPELLANT LEVEL IN THE LO2/LH2 EXTERNAL TANKS DURING LOADING AND ASCENT. POINT SENSOR TRANSDUCERS ARE LOCATED IN THE ET AND ON THE ORBITER (LO2 17-INCH FEEDLINE) WITH SIGNAL CONDITIONING ELECTRONICS ON THE ORBITER TO MONITOR AND CONTROL LOADING AND DRAINING OF PROPELLANTS. SENSORS ARE REDUNDANT AT ALL CRITICAL LEVELS.

FOUR SENSORS IN THE ORBITER LO2 FEEDLINE AND FOUR IN THE BOTTOM OF THE ET LH2 TANK PROVIDE A SAFE BACKUP SSME CUTOFF SIGNAL TO PRECLUDE ENGINE PROPELLANT STARVATION, IN CASE A GUIDED (VELOCITY) MECO IS NOT ATTAINED. THE ECO LOGIC IS ARMED WHEN THE CALCULATED TOTAL PROPELLANT MASS REMAINING REACHES 32,000 LBS OR UPON SECOND ENGINE FAILURE FOLLOWING SRB SEPARATION. ANY TWO QUALIFIED LH2 OR LO2 DRY SENSORS WILL GENERATE A MECO COMMAND AFTER THE SYSTEM IS ARMED.

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LRU: LH2/LO2 LIQUID LEVEL SENSOR

ITEM NAME: LH2/LO2 LIQUID LEVEL SENSOR

CRITICALITY OF THIS

FAILURE MODE: 1/1

FAILURE MODE:

RUPTURE/LEAKAGE - ORBITER LO2 ECO SENSOR.

MISSION PHASE:

PL PRE-LAUNCH

LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102	COLUMBIA
103	DISCOVERY
104	ATLANTIS
105	ENDEAVOUR

CAUSE:

FATIGUE, MATERIAL DEFECT

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) N/A

B) N/A

C) N/A

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

POSSIBLE PREMATURE SHUTDOWN OF ALL SSMES DUE TO LOSS OF PROPELLANT.
POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE.
POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD.
LEAKAGE IN THE AFT COMPARTMENT DETECTABLE DURING LOADING USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

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(B) INTERFACING SUBSYSTEM(S):
SAME AS A.

(C) MISSION:
ON GROUND, VIOLATION OF HGDS LCC WILL RESULT IN LAUNCH SCRUB.

(D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW/VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE ORBITER LO2 ECO SENSOR HAS TWO SENSING ELEMENT ASSEMBLIES CONTAINED WITHIN A FLANGE-MOUNTED 304 CRES HOUSING. AN MSFC SPEC 40M38294 ELECTRICAL CONNECTOR WITH FIVE GLASS SEALED PINS IS EB WELDED TO THE HOUSING, PROVIDING A SINGLE BARRIER AGAINST EXTERNAL LEAKAGE. STRUCTURAL ANALYSIS HAS NOT BEEN PERFORMED FOR THIS COMPONENT; HOWEVER, IT HAS SUCCESSFULLY PASSED THE QUALIFICATION BURST TEST AT 440 PSIG (2 TIMES OPERATING PRESSURE).

(B) TEST:
ATP - ELECTRONICS BOX

EXAMINATION OF PRODUCT
DIMENSIONAL
WEIGHT
TRACEABILITY RECORDS

ELECTRICAL CHARACTERISTICS
DIELECTRIC STRENGTH
INSULATION RESISTANCE

PERFORMANCE @ 28 VDC, 24 VDC, AND 32 VDC INPUT POWER
INVERSE VOLTAGE PROTECTION
CURRENT CONTROLLERS
WET/DRY TRIGGER LEVEL
POWER CONSUMPTION
OUTPUT SIGNAL PERFORMANCE
BUILT IN TEST EQUIPMENT (BITE) - OPERATION

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THERMAL CYCLE

+70 DEG F TO -60 DEG F TO +160 DEG F TO +70 DEG F
REPEAT PERFORMANCE TEST AT EACH TEMPERATURE

VIBRATION

RANDOM - FOR 30 SECONDS IN EACH OF THREE AXES

LEAKAGE - 15PSIG GHE

ATP - SENSORS

EXAMINATION OF PRODUCT

DIMENSIONS
WEIGHT
TRACEABILITY RECORDS

ELECTRICAL CHARACTERISTICS

DIELECTRIC STRENGTH
INSULATION RESISTANCE

THERMAL SHOCK (7 CYCLES)

AMBIENT (DRY GN2) TO LN2 TO AMBIENT

PERFORMANCE - LN2

RESPONSE (WET TO DRY) REPEAT 5 TIMES

PROOF PRESSURE (ORBITER UNIT; FLANGE AND CONNECTOR)

390 PSIG FOR 5 MINUTES

LEAKAGE (ORBITER UNIT; FLANGE AND CONNECTOR)

CRYO: 200 PSIG GHE @ -320 DEG F

D.C. RESISTANCE (SENSOR ELEMENT)

CERTIFICATION

RANDOM VIBRATION (POWER ON)

ELECTRONICS BOX - 48 MINUTES IN EACH OF 3 AXES
ET SENSORS - 3 MINUTES IN EACH OF 3 AXES IN LHE
- 3 MINUTES IN EACH OF 3 AXES IN LN2
ORBITER SENSOR - 48 MINUTES IN EACH OF 3 AXES IN LN2
ELECTRONICS BOX (QAVT) - 5 MINUTES IN EACH OF 3 AXES

RANDOM VIBRATION (POWER OFF)

ET SENSORS - LH2 3 MINUTES IN EACH OF 3 AXES @ 360 DEG F
- LO2 3 MINUTES IN EACH OF 3 AXES @ 500 DEG F

SINUSOIDAL (ELECTRONICS BOX AND ORBITER SENSOR)

5 TO 35 HZ

MECHANICAL SHOCK (MIL-STD-810)

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DESIGN

ELECTROMAGNETIC COMPATIBILITY (ELECTRONICS BOX ONLY)
CONDUCTED AND RADIATED INTERFERENCE AND SUSCEPTIBILITY PER MIL-STD-462

THERMAL CYCLE (ELECTRONICS BOX ONLY) - 40 CYCLES
AMBIENT TO +165 DEG F TO -65 DEG F TO +165 DEG F TO AMBIENT
PERFORM ATP PERFORMANCE TEST @ EACH TEMPERATURE EVERY 10 CYCLES

PERFORMANCE

ELECTRONICS BOX - REPEAT ATP PERFORMANCE TEST
ET SENSORS

LO2 UNIT - REPEAT ATP PERFORMANCE IN LO2
LH2 UNIT - REPEAT ATP PERFORMANCE IN LH2

ORBITER SENSORS

PERFORM RESPONSE FLOW TEST IN 6 INCH DIAMETER PIPE WITH
LO2 - REPEAT 5 TIMES

SENSOR

VERIFY UNIT RESISTANCES
EXPOSURE TO HIGH VELOCITY FLUID

ORBITER - 27 FT/SEC LN2

ET - 3 FT/SEC LN2

EXPOSURE TO HIGH PRESSURE

ORBITER (LO2) - 260 PSIA

ET (LO2) - 75 PSIA

ET (LH2) - 50 PSIA

SENSOR INTEGRATED SYSTEMS TEST (IN LH2/LO2)

RAISE AND LOWER FLUID PAST SENSOR CLUSTERS TO SIMULATE ET
FILLING AND DRAINING OPERATIONS

ORBITER SENSORS

TERMINAL DRAIN FLOW TEST IN LO2 USING 17 INCH O.D. LINE AND
SIMULATED VEHICLE (ET/ORB) CONFIGURATION. VERIFY SENSORS
PERFORMANCE

EXPLOSIVE ATMOSPHERE (SENSORS)

LH2 UNIT - GH2/AIR MIXTURE @ 160 DEG F FOR 2 MINUTES USING 12 VDC

LO2 UNIT - (ET) GO2 @ 500 DEG F AND 25 PSIG

(ORB) GO2 @ 200 DEG F AND 25 PSIG

SENSING ELEMENTS POWERED WITH 14.5 VDC

OPERATING LIFE

ORBITER ELECTRONICS BOX

600 HOURS TOTAL (POWER ON)

300 CYCLES - 2 HOURS POWER ON; 1 HOUR POWER OFF

50 CYCLES - AMBIENT TO VACUUM

PERFORM POST TEST BOX CHECKOUT WITH CHECKOUT
COMMANDS ONCE EACH DAY

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ET SENSORS (TEST FLUID: LN2/LH2)

19 HOURS OF 1 MINUTE WET AND 1 MINUTE DRY CYCLES; WARM UP TO AMBIENT EVERY 6 HOURS. LAST CYCLE WARM UP TO 500 DEG F (LO2 UNIT), 360 DEG F (LH2 UNIT)

ORBITER SENSORS (TEST FLUID LN2)

62.5 HOURS OF 1 MINUTE WET AND 1 MINUTE DRY CYCLES; WARM UP TO AMBIENT EVERY 6 HOURS. LAST CYCLE WARM UP TO 200 DEG F.

BURST (ORBITER SENSOR - FLANGE AND CONNECTOR)

440 PSIG

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED FOR MATERIALS AND PROCESS CERTIFICATION. CERTIFICATES AND RECEIVING RECORDS ARE MAINTAINED FOR VERIFICATION. SAMPLING TESTS ARE PERFORMED ON ELECTRONIC PARTS PER DRAWING REQUIREMENTS.

CONTAMINATION CONTROL

CLEANLINESS LEVELS OF SENSORS ARE VERIFIED TO 400 FOR LH2 UNITS AND 800A FOR LO2 ET UNITS AND THE WETTED PORTION OF THE ORBITER LO2 ECO SENSORS.

ASSEMBLY/INSTALLATION

ALL SOLDERING IS INSPECTED TO NHB5300.4 (3A) REQUIREMENTS. ALL DIMENSIONAL, FINISHES AND TORQUE INSTALLATION REQUIREMENTS ARE VERIFIED. ALL SENSOR ELEMENT WELDS ARE INSPECTED WITH 7.5X MAGNIFICATION; SAMPLE WELDS ARE VERIFIED BY PULL TESTS. THE WELD ATTACHMENTS TO THE ELECTRICAL CONNECTOR PINS ON THE ORBITER SENSOR ARE 100% PULL TESTED. CONTINUITY OF SENSOR SUBSTRATE ELEMENT GOLD PATHS IS VERIFIED. WIRE TO TERMINAL POST WRAP IS CHECKED WITH 7.5X MAGNIFICATION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESS

BRAZED AND WELDED SENSING WIRE TERMINATIONS ARE INSPECTED IN COMPLIANCE WITH DRAWING REQUIREMENTS. SWAGED TERMINAL POSTS OVER TERMINAL WASHERS ARE VERIFIED PER REQUIREMENT. ELECTRON BEAM WELDING IS VERIFIED ON ORBITER SENSOR HOUSING. ELECTRO CHEM-ETCH PROCESS IS VERIFIED.

NONDESTRUCTIVE EVALUATION

HELIUM LEAK DETECTION IS CONDUCTED ON ELECTRONICS BOX AND ORBITER SENSOR HOUSINGS. RADIOGRAPHIC AND DYE PENETRANT OF EB WELDS ARE VERIFIED.

TESTING

ATP IS PERFORMED AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING

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PARTS PACKAGED AND PROTECTED TO APPLICABLE REQUIREMENTS ARE VERIFIED. SPECIAL HANDLING PER DOCUMENTED INSTRUCTIONS IS VERIFIED TO PRECLUDE DAMAGE, SHOCK AND CONTAMINATION DURING HANDLING/SHIPPING/PACKAGING BETWEEN WORK STATIONS.

(D) FAILURE HISTORY:

TWO LO2 ECO POINT SENSORS FAILED ATP LEAK TESTS AT THE SUPPLIER DUE TO LEAKING ELECTRICAL CONNECTORS. THE CAUSE OF THE LEAKS WAS SUSPECTED TO BE A RESULT OF OVERLY SEVERE THERMAL SHOCK TESTS (IMMERSION IN LN2 WITHOUT TEMPERATURE PRECONDITIONING). CORRECTIVE ACTION WAS TO ADD A COOL DOWN PERIOD PRIOR TO SUBMERSION IN THE LN2 (CAR A6220 AND A6287).

ANOTHER LEAKING CONNECTOR AT THE SUPPLIER WAS UNCOVERED DURING THE FOURTH REWORK OF A QUAL UNIT. THE FAILURE WAS TENTATIVELY ATTRIBUTED TO IMPROPER HANDLING AND THE UNIT WAS SCRAPPED (DR AC5299).

CURRENT DATA ON TEST FAILURE, FLIGHT FAILURE, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

(E) OPERATIONAL USE:

FLIGHT: NO CREW ACTION CAN BE TAKEN.

GROUND: GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE OXYGEN SYSTEM.

- APPROVALS -

S&R ENGINEERING	: W.P. MUSTY	: /S/ W. P. MUSTY
S&R ENGINEERING ITM	: P. A. STENGER-NGUYEN	: /S/ P. A. STENGER-NGUYEN
DESIGN ENGINEERING	: HERB WOLFSON	: /S/ HERB WOLFSON
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: JEFF MUSLER	: /S/ JEFF MUSLER
USA SAM	: MIKE SNYDER	: /S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS